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(54) **Electroluminescent display**

(57) Present electroluminescent displays often suffer from seeded breakdown, that is breakdown at one point inducing similar breakdowns in the surrounding area, the damaged area spreading across the display. This invention limits such spreading by incorporating in the display a perforated dielectric layer (4) in the electric field which limits the high intensity field to small regions in the electroluminescent material (6) and therefore confines any seeded breakdown to one region. Each region alone does not make a substantial contribution to the display.

Fig 2

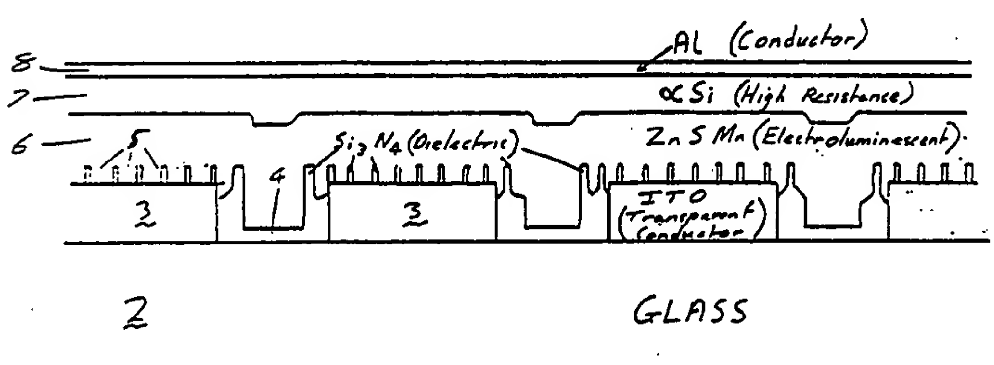

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Fig 1 (PRIOR ART)

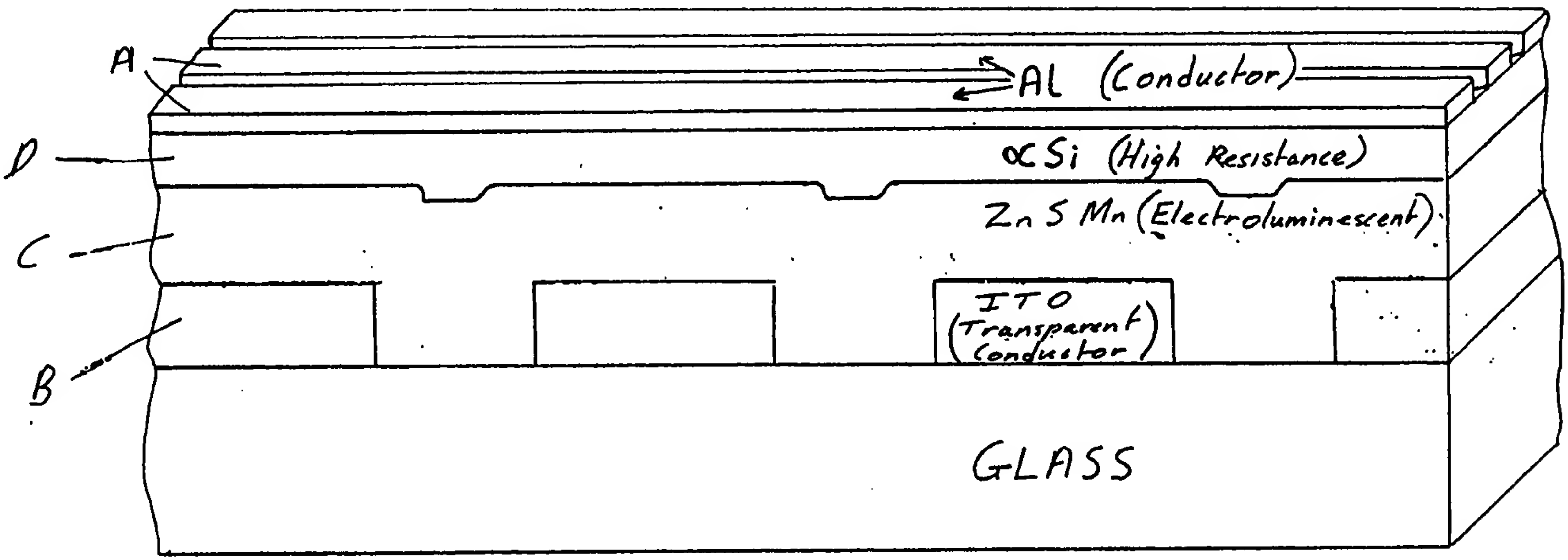
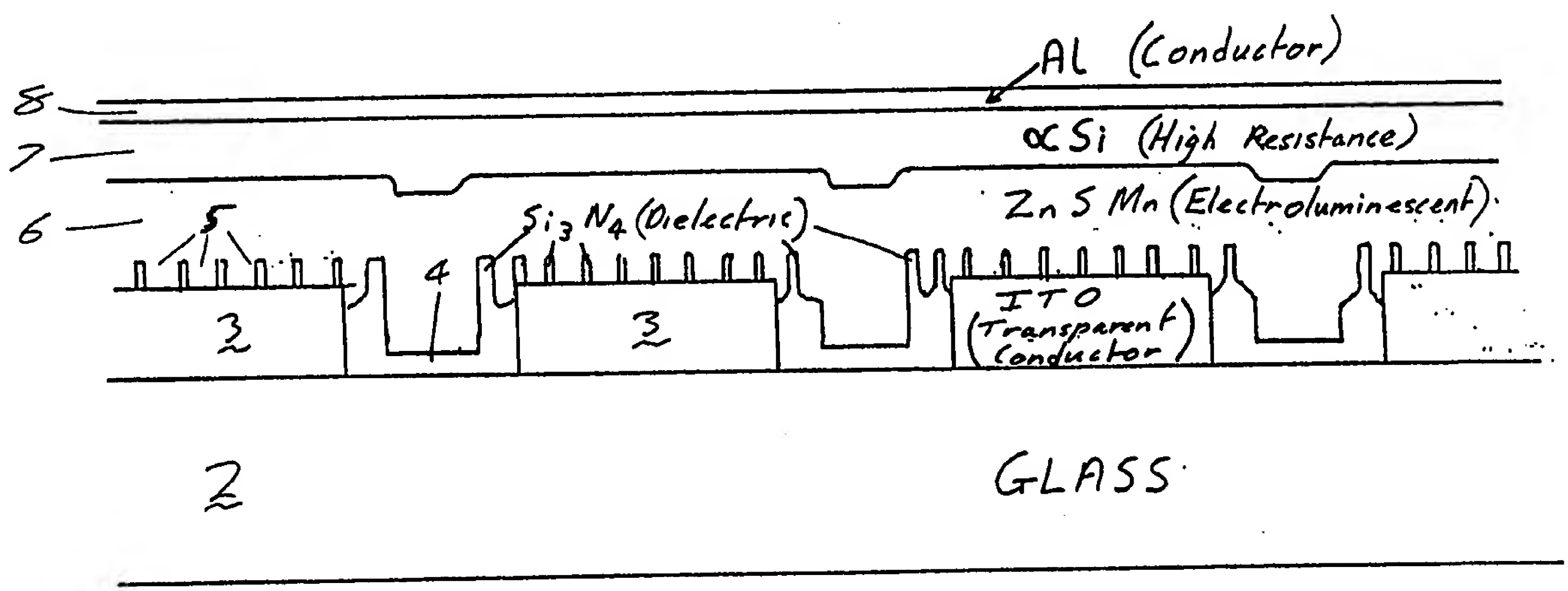


Fig 2



AL (Conductor)
αSi (High Resistance)
ZnS Mn (Electroluminescent)
Si_3N_4 (Dielectric)
ITO (Transparent Conductor)
GLASS
8
7
6
5
4
3
3
2

Fig 3

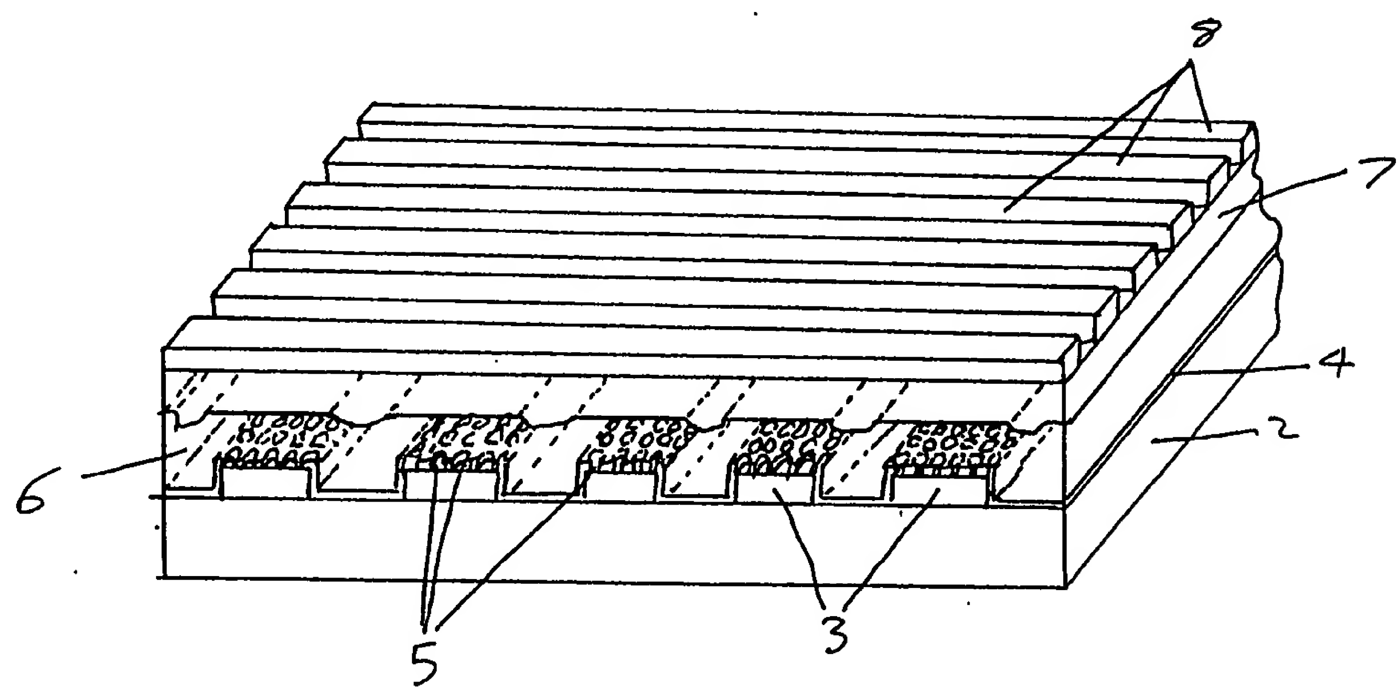


Fig 4

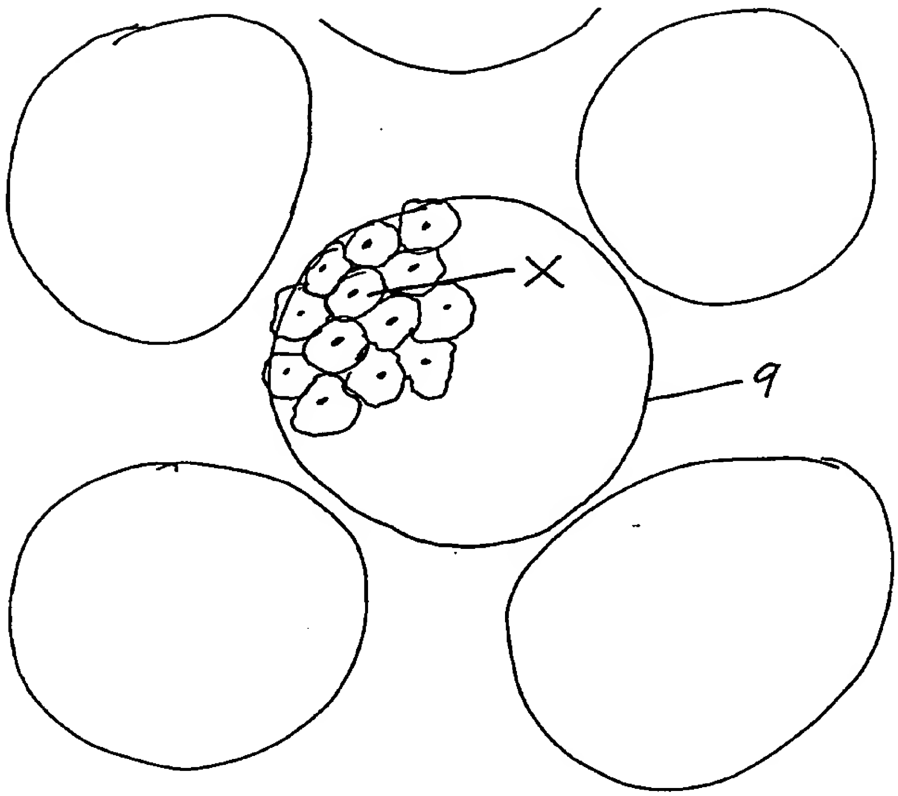
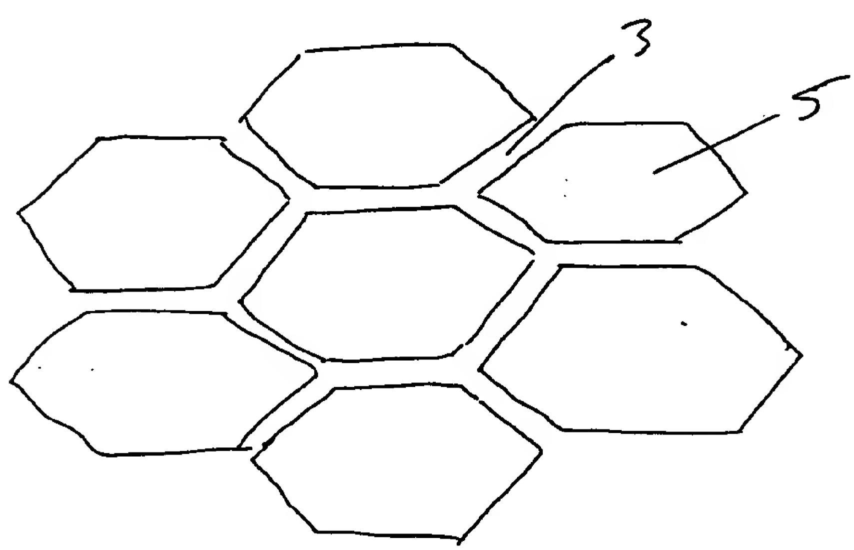


Fig 5.



Electroluminescent Display

This invention relates to electroluminescent displays, and particularly but not exclusively to directly coupled thin film displays.

Electroluminescent displays have many possible applications offering a bright, flat display with a wide angle of view.

Such a display is shown in Figure 1 and functions by an electric field being applied in a multiplexed matrix addressed manner between aluminium electrodes A and transparent indium tin oxide (ITO) electrodes B across a zinc sulphide and manganese doped phosphor layer C, which electrolumineses on application of a high enough field for its manganese ions to be excited.

The application of a high electric field across the thin film ZnS :Mn layer ultimately results in breakdowns in the layer which eventually determines the life of the displays. These breakdowns are caused either by intrinsic failure modes, due to initial properties of the ZnS:Mn compound or changes in the properties with

time due to the applied electric field, and extrinsic failure modes due to the manufacturing process, such as film thickness variation and impurities.

One type of breakdown which occurs is a propagating breakdown often initiated by a pin hole short through the ZnS:Mn layer. This type of breakdown propagates due to the high field at points on the edge of the breakdown region which spreads across the device. A known method of greatly reducing this failure mode is to incorporate an amorphous silicon layer D which has a relatively high resistance and thus limits the current being drawn in the breakdown region, preventing its spread.

Since a propagating breakdown can be restricted by the above method the life of a display is now substantially determined by the spread of seeded breakdowns. These occur about an initial point breakdown or pinhole breakdown when, due to increased current loading or heating in the surrounding area, another breakdown occurs at an adjacent point which is weak due to for example film thickness fluctuations or impurities. This in turn often leads to another adjacent breakdown and the seeded breakdown area spreads across the display, eventually affecting the visual

characteristics of the display.

It is an object of the present invention to limit the spread of a seeded breakdown in electroluminescent displays to such an extent that it does not significantly affect the visual characteristics of the display.

According to the invention there is provided an electroluminescent display comprising two electrodes separated by at least a layer of dielectric material having a plurality of perforations and a layer of electroluminescent material arranged such that when an electrical field is applied between the electrodes the perforated layer permits excitation in the electroluminescent material only in regions substantially defined by the size and shape of the perforations in the dielectric layer.

In operation, when an electric field is applied to an area, that field in the electroluminescent layer substantially defined by the perforations in the perforated dielectric substrate is greater than in those areas not so defined, the field being less in regions other than the defined ones due to the intervening

dielectric material. This restriction of the high field to small limited regions within the electroluminescent material restricts the growth of a seeded breakdown in one of the regions to that region only since the probability of breakdown in a low field region is very small. This therefore prevents a seeded breakdown spreading further than the single defined region in which it originated and therefore also limits edge effects at the boundary of an area forming a pixel to be illuminated.

Preferably, but not necessarily, each region is of a diameter less than 100 μm so that it cannot be resolved by the human eye at a normal working distance in use and will therefore not affect the visual characteristics of the display.

Embodiments of the invention will now be described by way of example only with reference to the accompanying drawings in which:

Figure 1 shows a perspective view of a prior art electroluminescent display.

Figure 2 is a sectional view of a thin film

directly coupled electroluminescent display in accordance with the invention.

Figure 3 is a perspective view of the display shown in Figure 2.

Figure 4 is a schematic plan view of an area of electroluminescent film, in use, undergoing a seeded breakdown, and;

Figure 5 is a plan view of an alternative arrangement for a dielectric substrate.

With reference to Figure 2 a directly coupled thin film electroluminescent display comprises a glass substrate 2 on which are mounted indium tin oxide conductors 3. A dielectric film 4 is deposited on the substrate and conductors, and is etched to form perforated regions 5. Although only nine such perforated regions are shown on each conductor 3 there would in practice be many more. A possible width of the conductor is 1 mm while the diameter of a perforation is typically 100 μm or less, preferably 50 μm, but in certain applications the diameter could be greater than 100 μm. The thickness of the film 4 is of the order of

0.1 μm.

The film 4 is then covered in a layer of electroluminescent material, typically ZnS:Mn, 6, which in turn supports a layer of amorphous silicon 7, on top of which are aluminium conductors 8 running generally perpendicular to the ITO conductors 3. It will be realised though that dielectric layer 4 may lie in any layer between the electrodes 3 and 8.

The same display is shown in perspective in Figure 3.

The electroluminescent layer, in operation, is effectively pixelated, each pixel corresponding to the cross over point of an ITO conductor 3 and an aluminium conductor 8 and can be addressed and illuminated by a DC electric field being applied between appropriate conductors in a known manner. This is known as a directly coupled electroluminescent display.

The layer 7 of amorphous silicon has a high resistance and limits propagation breakdowns by limiting the currents to any one point as described above.

The dielectric layer 4 reduces the field across the electroluminescent layer 6 and so in operation the field is strongest in regions (i.e. columns) defined by the perforations 5. As indicated in Figure 4, which is a schematic plan of a seeded breakdown in the electroluminescent layer 6, a breakdown starting at point X will not spread out of a region indicated by the circle 9 in which a high electric field exists and therefore such a seeded breakdown will be limited to the defined region.

An alternative arrangement of the dielectric layer 4 is shown in Figure 5 where the perforations 5 are of hexagonal shape to increase the surface area of the display illuminated, but any other desired shape of perforation could be used.

The invention is also applicable to other types of electroluminescent displays such as indirectly coupled AC devices in which the electric field is produced by capacitance effects either side of the electroluminescent material such as described in "Flat Panel Displays and CRT's" by Lawrence E. Tannas, Chapter 8, Section 4 Van Nostrand Reinhold 1985.

CLAIMS

1. An electroluminescent display comprising two electrodes separated by at least a layer of dielectric material having a plurality of perforations and a layer of electroluminescent material arranged such that when an electrical field is applied between the electrodes the perforated layer permits excitation in the electroluminescent material only in regions substantially defined by the size and shape of the perforations in the dielectric layer.

2. An electroluminescent display as claimed in Claim 1 which is a matrix addressed display comprising two sets of substantially orthogonal electrodes.

3. An electroluminescent display as claimed in Claims 1 or 2 wherein each region is of such a diameter that it cannot be resolved by the human eye.

4. An electroluminescent display as claimed in any of Claims 1 to 3 wherein each region is of a diameter less than 100 μm.

5. An electroluminescent display as claimed in any of

Claims 1 to 4 which is a thin film display.

6. An electroluminescent display as claimed in any of the preceding claims which is a directly coupled display.

7. An electroluminescent display as claimed in any of Claims 1 to 5 which is a capacitively coupled AC display.

8. A method of producing an electroluminescent display as claimed in any of Claims 1 to 7 wherein the perforations are produced by etching.

9. An electroluminescent display substantially as hereinbefore described with reference to and as illustrated by Figures 2 to 5 of the accompanying drawings.